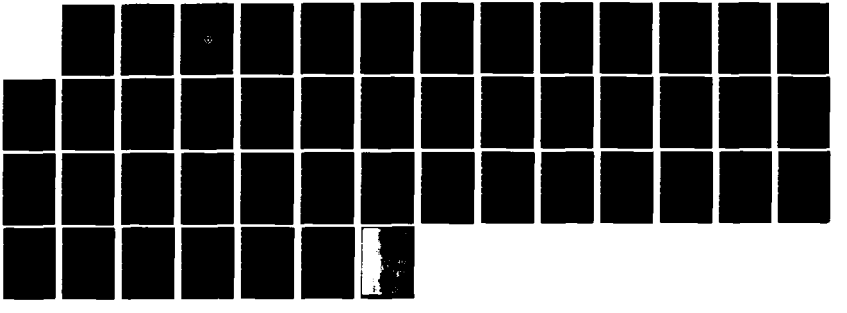
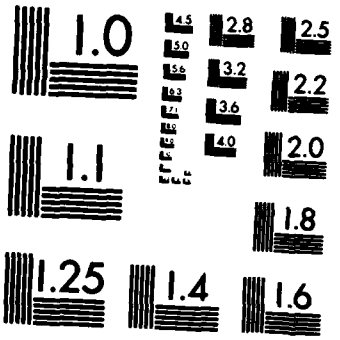
AD-A128 957 SOFTWARE TECHNOLOGY FOR ADAPTABLE RELIABLE SYSTEMS (STARS) FUNCTIONAL TAS.. (U) OFFICE OF THE DEPUTY UNDER SECRETARY OF DEFENSE RESEARCH AND E.. 30 MAR 83 1/1

UNCLASSIFIED F/G 9/2 NL





UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1 REPORT NUMBER	2 GOVT ACCESSION NO. AD-A128957
3 RECIPIENT'S CATALOG NUMBER	
4 TITLE (and Subtitle) Software Technology For Adaptable Reliable Systems (STARS) Functional Task Area Strategy For PROJECT MANAGEMENT	5 TYPE OF REPORT & PERIOD COVERED
	6 PERFORMING ORG. REPORT NUMBER
7 AUTHOR(s) The DoD Joint Service Task Force on the Software Initiative (STARS)	8 CONTRACT OR GRANT NUMBER(s)
PERFORMING ORGANIZATION NAME AND ADDRESS	10 PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
CONTROLLING OFFICE NAME AND ADDRESS Deputy Undersecretary of Defense Research & Advanced Technology Washington, D.C. 20301	12 REPORT DATE March 30, 1983
	13 NUMBER OF PAGES 45
14 MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15 SECURITY CLASS (of this report) Unclassified
	15a DECLASSIFICATION/DOWNGRADING SCHEDULE

16 DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17 DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Unclassified

18 SUPPLEMENTARY NOTES

19 KEY WORDS (Continue on reverse side if necessary and identify by block number)

Ada, STARS, embedded computers, military systems, KIT, KITIA, KAPSE, software initiative, automated support environments, mission critical, life-cycle costs, system interface standards, standardazation, functional task area, human engineering, human resources, management functions.

20 ABSTRACT (Continue on reverse side if necessary and identify by block number)

This document identifies the scope, sub-objectives and strategies designed to provide the conceptual approach for accomplishment of the STARS Program objectives in the project management functional task area. It identifies and describes the high-level activities, products and capabliities. This funcitonal task area strategy describes the broad, achievable requirements for accomplishing the relevant STARS objectives. Its main purpose is to help guide the implemenation planning process.

DD FORM 1473 EDITION OF 1 NOV 65 IS OBSOLETE

S/N 0102-LF-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

SOFTWARE TECHNOLOGY FOR

ADAPTABLE, RELIABLE SYSTEMS (STARS)

FUNCTIONAL TASK AREA STRATEGY FOR

PROJECT MANAGEMENT

Department of Defense

30 March 1983

FOREWORD

This strategy document is one of eight functional task area strategies produced by the STARS Joint Task Force. All of the documents produced by the Task Force, including the general STARS Program Strategy document, are listed in the STARS Joint Task Force Report.

This document identifies the scope, sub-objectives and strategies designed to provide the conceptual approach for accomplishment of the STARS Program objectives in the project management functional task area. It identifies and describes the high-level activities, products and capabilities. In order to provide full understanding, background and rationale material is sometimes covered that is also in STARS Program Strategy.

These functional task area strategy documents do not attempt to delineate the detailed plans, costs and procedures for bringing the proposed products and capabilities into being and do not identify the form of the particular projects that will undertake the work nor the organizations in which the work will be accomplished. Instead, these strategies are intended to guide the process of such implementation planning and accomplishment.

Indeed, because of the high degree of linkage among the functional task areas, implementation plans and acquisitions may well combine related capabilities and products across areas. Individual projects may tackle only part of one subtask from a functional area or several subtasks from several functional areas.

Thus, this functional task area strategy describes broad, achievable requirements for accomplishing the relevant STARS objectives. Its main purpose is to help guide the implementation planning process.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF ILLUSTRATIONS

LIST OF TABLES

1.0 INTRODUCTION

1.1 Objectives

The overall objective of this task area should be to improve the practice of project management to contribute to the goals of:

- o shorter schedules
- o higher quality products
- o greater cost effectiveness
- o better forecasting
- o increased product knowledge transfer.

The objective would be accomplished by producing and making available to project managers tools, methodologies, models, and training programs designed to achieve the goals.

1.2 Background

Software system development and support projects differ in one major respect from other system projects. In most other technologies, component development and systems development are separate functions. In these technologies systems are developed by integrating and interfacing known components. This is not usually the case in software systems. In software systems the components are modules. In general these modules are under development concurrently with the system development, so the system designer is trying to integrate and interface components which are not well understood. These uncertainties cause software project development to be considerably complex. Software system designers usually specify the components to support the system concepts rather than designing the system around components with already fixed characteristics. The usual result is that some software modules cannot be developed to meet the specifications provided by the system designers. The system designers must then

alter the system design which effects other modules and their development. The effect on planning, scheduling, and costing of this kind of activity is significant. In post-delivery support, the planning scheduling and costing problems are still severe because the trade-off's and design decisions made during development, for the previously stated reasons, result in a product that is not well understood and is many times a collection of undocumented compromises to a straight forward design. For these reasons the complexities of software project management require innovative tools and management skills.

This task area is concerned with issues relating to both the system buyer and the system producer as well as their interface both with each other and up and down their respective management chains as illustrated in Figure 1-1. The Project Management Functions that are objects of concern are the planning, control, decision making, personnel management and leadership that are necessary to control the excecution of software project life cycle functions within cost and schedule constraints. The management fuctions that are the subject of this task area are separated from acquisition functions which are the subject of the acquisition task area as shown in Figure 1-2.

People who carry out the Project Management Functions are identified by a set of titles which lack consistency both within the DoD and within industry. In addition the Project Management Functions are generally performed by more than one person within the buyer and producer organizations depending on their individual organizational structures. People within DoD who perform Project Management Functions may have titles which include: program manager, project manager, project engineer, acquisition manager, acquisition engineer, department head, branch head, or section head. People within the producer organization may have similar titles, but "project manager" is more or less standard. For the purpose of this plan the people

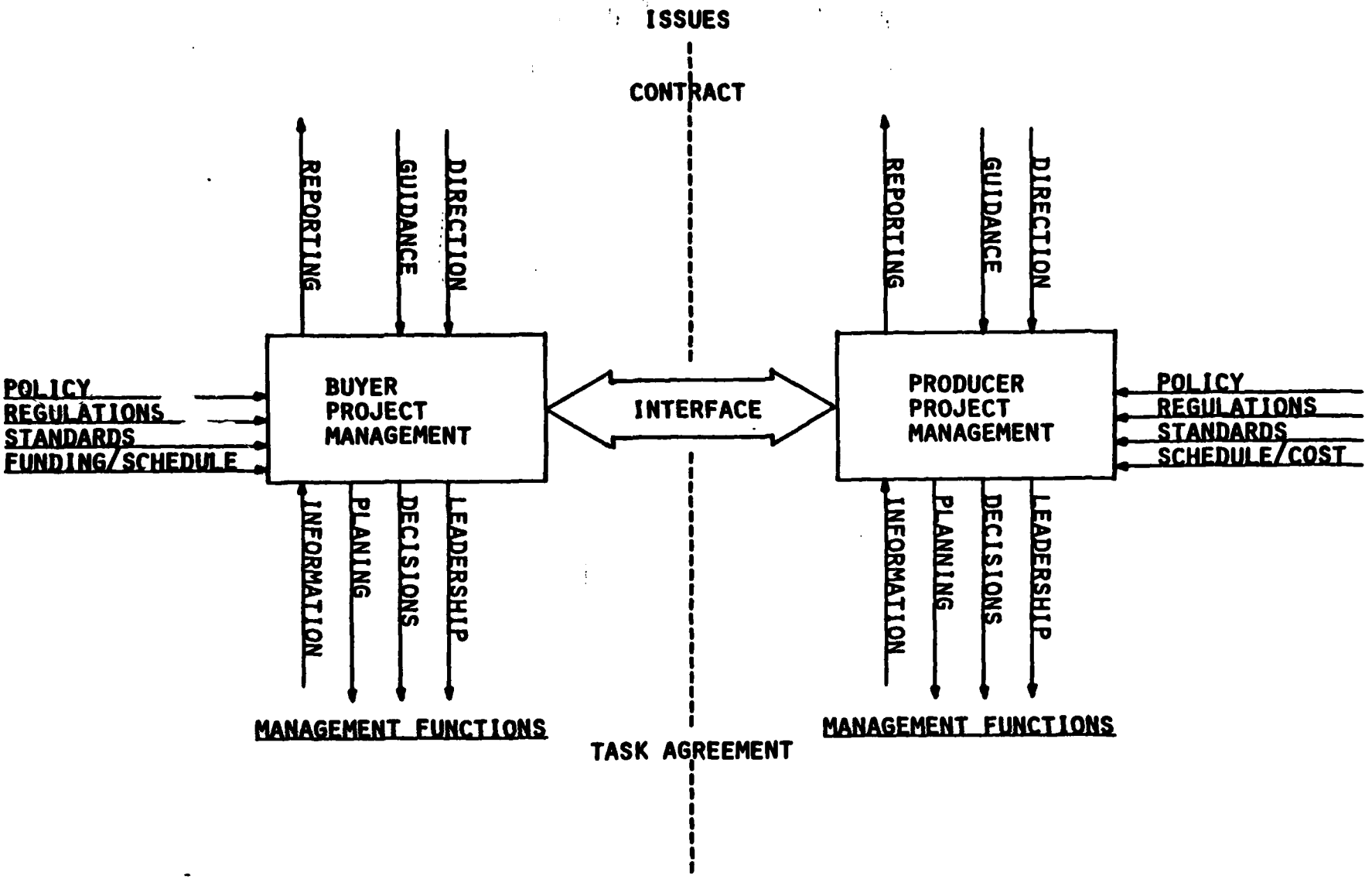

ISSUES
CONTRACT
REPORTING
GUIDANCE
DIRECTION
POLICY
REGULATIONS
STANDARDS
FUNDING/SCHEDULE
BUYER
PROJECT
MANAGEMENT
INTERFACE
PRODUCER
PROJECT
MANAGEMENT
POLICY
REGULATIONS
STANDARDS
SCHEDULE/COST
INFORMATION
PLANING
DECISIONS
LEADERSHIP
MANAGEMENT FUNCTIONS
INFORMATION
PLANNING
DECISIONS
LEADERSHIP
MANAGEMENT FUNCTIONS
TASK AGREEMENT

FIG. 1-1

SCOPE

- PROJECT MANAGEMENT ENCOMPASSES THE PLANNING, CONTROL, DECISION MAKING, PERSONNEL MANAGEMENT AND LEADERSHIP FUNCTIONS NECESSARY TO CONTROL PROJECT EXECUTION INCLUDING:
  - REQUIREMENTS DEFINITION
  - DESIGN
  - DEVELOPMENT
  - IMPLEMENTATION
  - TEST AND EVALUATION
  - POST DEVELOPMENT SUPPORT

  WITHIN COST AND SCHEDULE CONSTRAINTS

  ACQUISITION ENCOMPASSES THE FORMAL FUNCTIONS RELATED TO ESTABLISHING LEGAL CONTRACTS BETWEEN DOD AND INDUSTRY INCLUDING:
  - REQUESTS FOR PROPOSALS
  - SOURCE SELECTION
  - NEGOTIATION
  - AWARD
  - TERMINATION

  WITHIN LEGAL CONSTRAINTS

FIG. 1-2

who carry out Project Management Functions are the Buyer's manager and the Producer's Manager.

The Buyer's Manager and Producer's manager must carry out mutually supportive Project Management Functions while receiving guidance and direction from different superiors, reporting to different higher authority, and adhering to different policy, regulations, standards, schedules, resource constraints, and motivational factors. The flow of project information across the buyer/producer interface can be strongly influenced by the differences in the buyer and producer environments.

There are at least four buyer/producer relationships that must be considered in analysing the project management function. These relationships are identified in Table 1-1. The first of these relationships is characterized by the fact that the contractor is responsible for the total system, including the acquisition or development of all components, system integration, installation, check-out and functional demonstration.

The second relationship is characterized by the fact that some aspects of system integration and functional demonstration are the responsibility of the buyer. The third and fourth relationships are characterized by the fact that both buyer and producer are within the DoD. The second, third and fourth relationships are more typical of the software support (redevelopment) phase.

Although the Project Management Functions which must be performed to accomplish a given project are independent of the buyer/producer relationship, the responsibilities, authority and granularity of management control relative to specific phases of the lifecycle vary between buyer and producer, depending on the buyer/producer relationship. The capability of the buyer and producer manager to mutually support each other is dependent on the

BUYER/PRODUCER RELATIONSHIPS

BUYER	PRODUCER
• DOD ACTIVITY	CONTRACTOR WITH "TURN KEY" CONTRACT
• DOD ACTIVITY	MULTIPLE CONTRACTORS
• DOD ACTIVITY	ANOTHER DOD ACTIVITY
• DOD ACTIVITY	SAME DOD ACTIVITY

TABLE 1-1

effectiveness of the buyer/producer interface. This task area plan will use the first of the four identified buyer/producer relationships as a model for further planning but will be sensitive to the character of all four relationships and the effect that they have on Project Management Functions.

1.3 Problem and Opportunity Areas

Problem areas are the same as the opportunity areas since each problem presents an opportunity for its solution. Five typical problem (opportunity) areas are identified in this section.

1.3.1 Low Visibility: Nobody Knows What's Going On

Software is silent and invisible and the development project structure is most often ad hoc. It is difficult for the Buyer's manager to get answers to important questions such as: Who is making the technical decisions? Who reviews them? What are the consequences of observed schedule slippages? Do the decision makers always have the right information? Is the system under development going to make its performance goals? Would more people help? Are we in trouble? If so, what corrective actions can be taken?

Given the poor reporting and ad hoc management structure of many software development projects, it is doubtful if anyone within the project knows the answers to these questions. It is not because he is unwilling that the Producer's manager does not provide answers, it is because he is ignorant of the answers.

1.3.2 Poor Forecasting: Nobody knows what's coming next

Time and cost overruns are common in software projects and seem to occur whether or not an automated resource estimating (or cost estimating) tool is used. Models underlying the resource estimating tools are poorly defined and often use unmesaurable parameters. It is not just that cost estimating tools are poor and must be improved.

The problem is that ad hoc methods of software design and project organization cannot be modeled accurately and so cost estimating tools are inappropriate to them.

1.3.3 Inadequate Product: Nobody Knows If It Will Work

Two ways that a product can fail to "work" are 1) failure to meet the needs of its users and 2) intractability in the face of needed post-delivery modifications. Both these types of failure can be attacked by project management techniques based upon software engineering.

1.3.4 Poor Organization: Nobody Knows Who's In Charge

The term "adhocracy" has been coined to describe the cadre of managers who arrived at their positions through ad hoc appointments. Very often these ad hoc appointments are poorly defined so that, for example, a Senior Software Engineer may be given "complete technical responsibility" without the budgetary authority to implement his decisions. In order for project organization to be effective, communication and control lines within the project must be explicit so that guidance flows to the real decision makers.

1.3.5 People Problems

Project Managers need career development. One consequence of ad hoc appointments is that managers are often lacking some educational prerequisite for their jobs. Software professionals lack basic management skills and management professionals often know little of software technology. Within the DoD, software development and redevelopment are often hampered by ignorance of military applications and doctrine.

1.4 Strategy

Automation of existing practices would not be goal of the Project Management Rather, the goal should be to investigate candidate

strategies for better project management and improved organization, and then determine what automated tools and skills are required to support them. Too much concentration on existing tool sets should be avoided, since these tool sets may implicitly encourage the use of outmoded methodologies. Methodologies should dictate tool development, not the other way around.

The strategy begins with a functional analysis of project activity. The results of the analysis are embodied in a set of Project Models, which become the driving force of the strategy. The models developed at the inception of the task strategy are used as a unifying principle throughout. At a late stage in the work these models would be automated and become the integrating component of an Advanced Project Management Tool Set.

The strategy consists of three tasks:

a. A Project Management Functional Analysis

b. The Development of Project Management Tools and

c. The Development of Management Skill Educational Concepts.

These tasks are identified in Figure 1-3.

TASKS

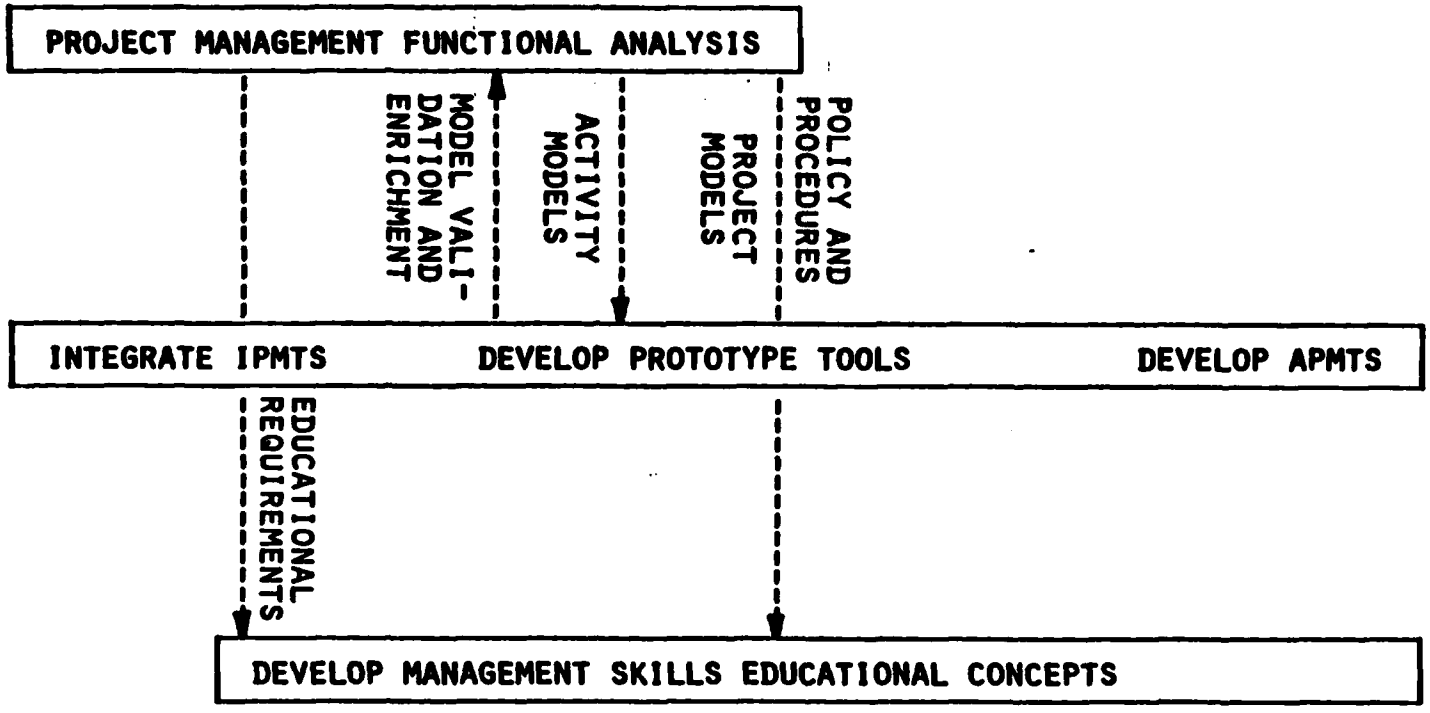

PROJECT MANAGEMENT FUNCTIONAL ANALYSIS
MODEL VALI-DATION AND ENRICHMENT
ACTIVITY MODELS
PROJECT MODELS
POLICY AND PROCEDURES
INTEGRATE IPMTS
DEVELOP PROTOTYPE TOOLS
DEVELOP APMTS
EDUCATIONAL REQUIREMENTS
DEVELOP MANAGEMENT SKILLS EDUCATIONAL CONCEPTS

FIG 1-3

2.0 TASKS

2.1 Project Management Functional Analysis

The goal of this task would be to better the understanding of the project management function. The approach is to model projects in a way which provides a generic and consistent description of project activities and their relation to one another in both sequence and required coordination. The Project Model consists of two parts, a set of Activity Elements and the Policies and Procedures which define the interrelationship among the Activity Elements. The output of the task includes Project Models that can be used by managers for increased visability and better reporting. The Project Models also provide a basis for the development of automated project management tools.

The products to be developed are designed to lead to real time project management. Real time project management means that information is provided in a manner timely enough that corrective action may be taken in such a way that the overall schedule of the project is not affected. Real time project management will benefit both the buyer and the producer.

The objective of project management is to control the execution of activities to successfully accomplish each phase of the software lifecycle. Within a Project Model the Activity Elements define what is to be done. The Policies and Procedures are an expression of the manager's plan, including project implementation methodology, sequencing of activities, activity interfaces, and lines of control and reporting. In this way the Project Model describes what must be done, when it is to be done and how it is to be done. Because the project management function is to define what is to be done (activities), plan how and when it is to be done (policy and procedures), monitor progress and redefine and replan as required, the Project

Model is a useful way of understanding the project management function.

The two parts of the Project Models (Activity Elements and Policies and Procedures) must be carefully constructed in order to avoid modeling ad hoc organizations and perhaps institutionalizing them. The intent of project management functional analysis is to build the Project Models from coherent organizational structures based upon software design methodologies. Before a generally applicable set of Activity Elements can be constructed, two tasks must be accomplished. They are concerned with work breakdown structures and project documentation.

The set of Activity Elements in the Project Model are to be based upon a generic (or at least flexible) work breakdown structure. However, producing the generic WBS could best be done by generalizing or abstracting from the individual WBSs that are implied by the various software design methodologies to be studied. Moreover, each methodology would imply certain high level policies and procedures (e.g. "module decomposition first" or "design before code") that are to be associated with the WBS. The first task, therefore, would be to produce a set of WBS structures associated with software design methodologies and the high level policies and procedures that would be associated with them. The product of this task would chiefly be used as input to construction of the Project Models. However, it would be useful by itself since it would provide project managers with the organizational implications of their decisions concerning software design.

Because software production tends to be a document-driven activity, decisions on project documentation (including, but not limited too, documents that are delivered with the software) would have an influence on both the WBS and on policies and procedures. A task should be established to identify new and promising methods of

"design through documentation", to demonstrate their superiority over current methods, and to identify their impact on the WBS and on policies and procedures. As with the previous task, the output of the documentation task would be chiefly designed to be input to the Project Models, but it should also be useful on its own.

2.1.1 The Activity Element

The Activity Element has been chosen as a mechanism for identifying the component parts of a project and the attributes of those parts which form the knowledge base upon which management activities are carried out. The purpose of this task is to identify the activities on both sides of the buyer/producer interface which together make up each phase of the software lifecycle and to identify the attributes of those activities which can be used to measure and control the project. The structure of the Activity Element must be project independent. The structure consists of two parts, activity name and activity attributes.

The following are examples:

a. Activity Element #1
   Name: DoD Planning, Programming and Budgeting.
   Attributes: 1. Function of - Buyer Manager
   2. Schedule - 2 years prior to budget year
   3. Resources - 0.5 MY/Year

b. Activity Element #2
   Name: Code Module
   Attributes: 1. Function of - Programmer A
   2. Schedule - Test in 2 weeks
   3. Resources - 0.025 MY

Activity attribute values are project specific although the attributes themselves are not. The degree to which the semantics of each activity in the model must be captured is highly variable. Therefore, an initial version of the Activity Element can be very simple. As an example, if management needs only to know whether a particular computer program has been finished, is in progress, or hasn't been

started, then the Activity Element need contain only those three states, but none of the semantics of the activity "WRITE COMPUTER PROGRAM XX". The element need not know, for example, what the program does or who is writing it or how it's coming along or how good it is. On the other hand, if management needs to know how much of the activity has been completed or the quality of the work, then a much more detailed element would be required which would support the processing needed to form progress and quality estimates.

A salient feature of the Activity Elements that has been noted are their neutrality, that is, their independence from policies, procedures, management styles, management methodologies, and design technology. It is important that each Activity Element be generic in nature. This is because experience has shown that software tools implicitly require particular ways of doing things and so dictate methodology instead of the other way around. Activity Elements can be useful development tools, useful experimental prototypes, and testbeds for methodologies; all without constraining project management to any particular style and without making a commitment to any particular design philosophy. Activity Elements can provide the basis for a consistent structure (tool) for management data to allow real-time transfer of knowledge across the buyer/producer interface.

2.1.2 Policies and Procedures

Policies and Procedures define the sequence of project activities and the coordination and information trasnfer which must take place between activities. Policies and Procedures are the relational semantics of the Project Model. Policies and Procedures are project specific. They are strongly related to software engineering concepts and the design of the product.

If the elements of the Project Model are the building blocks of the project, then the Policies and Procedures, among other things, are the ways of connecting them up. As examples, consider:

a. administrative lines of control: these are policies.

b. reporting requirements: these are policies.

c. how the monthly report is produced: this is a procedure.

d. "design before code": this is a policy.

e. documentation is done on a word processor: this is a procedure.

f. use a particular design methodology: this is a policy.

g. programmers keep notebooks: this is a policy.

Policies and Procedures may be thought of initially as ways of connecting and coordinating the elements of the Project Model but this is actually an oversimplification. Policies and Procedures are needed in order to refine the attributes of the Activity Elements. This interplay between the elements of the Project Model and their relational semantics can be seen most easily when we consider the influence of software design methodology on project organization.

In the early 1960s it was often said that software systems resembled the organization charts of the groups that produced them. In more recent times this relationship has reversed itself and project organization tends to mimic the modularity of the software design. Thus if an avionics system is to be written and it is determined that the system will, at the highest level, be modularized into "weapons" and "navigation", the project will be organized into a weapons section and a navigation section with first-line managers for each. The work breakdown structure (or its equivalent) will also reflect this division. It is highly desirable that project organization be driven by the modularization of the software since a "module"

is a work assignment and organizing projects according to work assignments leads to an organization where there is a high degree of compatibility between the administrative lines of control and the flow of work. However, just as a poorly conceived decomposition of the system into modules leads to a system that is so highly connected that it is hard to maintain, the same poorly conceived modularization leads to a project organization with many crossing lines of control, poor communication and weak administrative links. Therefore, we regard software design methodology as one of the most important of the policies and procedures that we will consider.

The purpose of the Policies and Procedures subtask would be to identify project organizational success factors and to integrate them with the Activity Elements. The "project organizational success factors" are simply sets of Policies and Procedures that have worked successfully in real projects and have been identified and described.

In addition, certain concepts have already been identified as having so much potential for both achieving project success and delivery of high quality products that they have separate Policy and Procedures associated with them. One of these has already been mentioned: the influence of software design methodology on project organization. The others are concerned with documentation techniques, decision criteria for software module decomposition, program verification, software technology evaluation, and characterization of change. Each of these factors embodies Policies and Procedures that drive the organization of a project and contribute to its success or failure.

Policies and Procedures are constrained by buyer and producer organization; direction from superiors, reporting requirements to higher authority; buyer and producer corporate policies, regulations, standards, and schedules; resource constraints, and motivational factors. Policies and Procedures define the project organization,

documentation methods, and sequence related concepts such as design before code.

2.1.3 Model Validation

The next stop in understanding the project management function would be to validate the modeling techniques against known software engineering methods to see if the Activity Elements coupled with the Policies and Procedure would provide a generic way of defining the project. There are several questions to answer in our validation process:

a. Is the structure of the Activity Elements generic, i.e. independent of the Policies and Procedures?

b. Can projects be completely described by relating Activity Elements to Policy and Procedures?

c. Does the notion of Policy and Procedures work for a number of software engineering methodologies?

Feedback from the exercise of the Initial Project Management Tool set, described in section 2.2.1, can be used to enrich the semantic quality of the Project Model and validate the concept based on a limited set of real-world projects.

2.1.4 Deliverables

- Project Structures. Research results on work breakdown structures associated with software design methodologies and the high-level policies and procedures that they imply. Comparison of design methodologies with respect to work breakdown structure and policies and procedures. (Should be delivered by FY85.)

- Documentation Structures. Research results on improved documentation techniques, their impact on work breakdown structures, and their impact on policies and procedures. A set of model documentation would be delivered together with guidelines for using the techniques. (Should be delivered by FY86.)

- o Activity Elements. The Activity Elements to be delivered are conceptual but recommendations should be included for later automation. A format compatible with eventual implementation as a knowledge base is required. (Should be delivered by FY86.)

- o Policies and Procedures. Collected Policies and Procedures from several design methodologies with recommendations for their integration with the Activity Elements. (Should be delivered by FY87.)

- o Project Models. These conceptual models would be built by integrating the Activity Elements with methodology-specific Policies and Procedures. If necessary, high-level policies and procedures would be rewritten in order to be at the right level of detail to integrate the Acitivity Elements. (Should be delivered by FY87.)

- o Project Model Validation Plan and Results. The plan should specify how to test the delivered Project Models against known software engineering methods in order to determine if the Project Models provide a generic way of defining and modeling projects. The Results of Validation would contain recommendations concerning automation of one or more Project Models to form the Project Activity Coordinator of the Advanced Project Management Tool Set. (Should be delivered by FY88.)

2.2 Project Management Tool Set

2.2.1 Initial Project Management Tool Set

The first step in the development of project management tools would be the acquisition and exercise of one or more Initial Project Management Tool Sets. The tools for this initial tool set would be in the main off-the-shelf tools with a primary objective of the acquisition being to establish among the set of tools a common data base for interfacing the activities (input/output) associated with each tool. The acquisition should consist of two phases. First the evaluation and selection of candidate tools and second the system design and software effort to integrate and interface the tools. The second part of the Initial Project Management Tool Set effort is the exer-

cise of the tool sets on real DoD software acquisitions. The Initial Project Management Tool Set would not only provide a set of useful tools for today's manager, using today's methods, but would also provide a means for identifying opportunities for improving management methods and more powerful tools.

There are two critical aspects of the Initial Project Management Tool Set effort. The first is that the tool set must be common to both the buyer and producer, must be integrated with the development environment and be supported with a robust buyer/producer interface. The second is that the use of the tool set must capture significant knowledge about the influence of tools on management, the significance of information flow, and the shortcomings of off-the-shelf tools.

The Initial Project Management Tool Set represents a unique opportunity to capture knowledge of the management process of a real project. In order to enhance this capture a requirement of the Initial Project Management Tool Set should be that the tool set must provide the capability for generating and maintaining a time tagged data base (audit trail) of tool activity. The knowledge of the management process gained through use of the Initial Project Management Tool Set would support the validation of the results of task 2.1.

2.2.1.1 Users Group. A users group would be formed to support the DoD component responsible for managing the Initial Project Management Tool Set effort. The users group should be constituted of senior project managers from DoD and industry who are experienced in both software development and support. The users group would provide guidance on refining the requirements for the Initial Project Management Tool Set. This activity would include: identifying the types of tools, such as those identified in Table 2-1, which should form the basis of the Initial Project Management Tool Set, defining

Functional Capability	Summary Description
• Data Base Management	• Relational data manager with query features
• Word Processing	• Executive word processor with limited sophistication
• Word Pack	• Spelling and grammar checkers
• Telecommunication	• Processor to processor communications and electronic mail
• Graphics	• Business graphics generation and editor
• Electronic Worksheet	• Business spreadsheet calculator
• Interactive Work Planning	• Work Breakdown Structuring (WBS) generator and tracker
• Schedule Generation	• Bar and Gantt chart generation and editor
• Cost Estimation	• Quick-and-dirty cost estimator
• Margin Management	• Margin (memory, speed and input/output variances between actuals and goals) tracker
• Manpower Ranking and Rating	• Personnel ladder ranking and rating worksheets
• Management Information Reporting	• User defined and precanned report generators
• Configuration Management	• On-line problem reporting and change status accounting system
• Help	• Structured help generator
• Tutorial	• Pre-established examples used as learning aids

Table 2-1
INITIAL PROJECT MANAGEMENT TOOL SET
CANDIDATE TOOLS

requirements for the tool set user interface, defining requirements for a common tool set data base and defining requirements for an Initial Project Management Tool Set audit trail. The users group would provide guidance for defining learning objectives for the exercise of the Initial Project Management Tool Set. The users group would be a continuous function within the Project Management Tool Set effort. The group would support the source selection process with regard to the contractor developed Initial Project Management Tool Set and would review and comment on Initial Project Management Tool Set design documents, test and evaluation plans, and reports and exercise plans.

2.2.1.2 Acquisition Strategy. Criteria to be considered with regard to acquiring the Initial Project Management Tool Set are: the availability of off-the-shelf tools, the availability of an integrated software development environment, and a minimal impedance buyer/producer interface. Alternative acquisition strategies must be weighed against these criteria. Three approaches are identified:

a. Build on Automated Project Management tools in development by DoD components such as the Facility for Automated Software Production (FASP) work at the Naval Air Development Center and the Graphical Interactive Technique for Project Analysis, Scheduling and Evaluation (GITPASE) work at the Army Institute for Research in Management Information and Computer Sciences (AIRMICS). Exercise the resulting Initial Project Management Tool Set to manage a software development or support (redevelopment) effort within DoD, where both the buyer and producer are within DoD, to minimize buyer/producer interface problems.

b. Issue an RFP to competitively procure one or more Initial Project Management Tool Sets. Specify the use of the procured tool set as GFE on a contract for software development.

c. Add the requirement for developing and using an Initial Project Management Tool Set by the contractor and DoD manager to the RFP for a competitive procurement of a software intensive, mission critical system.

Based on an evaluation of the alternatives, the strategy for obtaining the Initial Project Management Tool Set is bidirectional. Two Initial Project Management Tool Set efforts should be undertaken. One effort would be directed toward an acquisition environment where both buyer and producer are within the DoD. The other effort would be directed toward an enviornment where the buyer is a DoD component and the producer is a contractor. Alternative (a) should be used for the first effort to develop a tool set which would identify DoD projects already in progress. On of these projects would be chosen to be expanded to meet Initial Project Management Tool Set requirements identified by the user group and interfaced with an internal DoD software development effort. The key to this interface is the identification of a DoD organic software project which makes use of an integrated software development environment. An integrated environment would reduce the tool set interface effort. Because both buyer and producer are within DoD, problems of proprietary or private data should not exist and the necessary real time free flow of data input to the tools should be realizable. The second effort would use alternative (c) and would be intended to leverage industrial efforts. Again one of the key elements in choosing alternative (c) is the need for the tools to have an effective interface with development data. The requirements for the Initial Project Management Tool Set identified by the user group should be added to the development statement of work and specifications. Software Initiative funds should be added to the funds available for the candidate systems development to offset the cost of the contractors efforts to integrate the tools and deliver the Initial Project Management Tool Set to the DoD project manager. Innovative acquisition practices must be employed to provide proprietary tools and private data for unrestricted DoD use while protecting industrial proprietary rights. In addition, the system development award must be made on a competitive basis and careful attention paid to the selection process to ensure the

selection of a contractor who can meet the Initial Project Management Tool Set requirements with already existing internally developed tools. It is critical that the contractor be able to deliver to the DoD manager a set of tools early in the contract and be willing to share development data in real time.

2.2.1.3 Initial Project Management Tool Set Exercise. Each of the two Initial Project Management Tool Set efforts must have an exercise plan and procedures which identify what is to be learned from use of the Initial Project Management Tool Set and how this knowledge is to be captured. The users group should help define the learning objectives and review the exercise plan and procedures. The Initial Project Management Tool Set exercise should take place over the life of the development or redevelopment effort. Interim reports would be generated to reflect experience gained and lessons learned about the tools and their interface withthe development support activity.

2.2.1.4 Deliverables.

- o Initial Project Management Tool Set: Industry. (Should be delivered by FY84.)
- o Initial Project Management Tool Set: DOD. (Should be delivered by FY85.)
- o Initial Project Management Tool Set Exercise Plan (Should be delivered by FY84.)
- o Initial Project Management Tool Set Exercise Results (Should be delivered semi-annually FY85-FY86.)

2.2.2 Advanced Project Management Tool Set

The concepts and requirements for an Advanced Project Management Tool Set are generated by the Project Management Functional Analysis Task 2.1 and the exercise of the Initial Project Management Tool Set. The Project Model which results from task 2.1 identifies project

activities and the information required to uniquely define the activity and its status. The Activity Elements define a knowledge base of project activity. Task 2.1 further defines the Policies and Procedures required to relate project activities. These Policies and Procedures are the Project Model relational semantics and would define the information flow and the types of coordination required and/or presecribed among the activities. The exercise of the Initial Project Management Tool Set would provide insight into issues such as:

a. timeliness of information flow across the buyer/producer interface;

b. perishability of status information;

c. interoperability of existing tools;

d. availability of information; and

e. usability of tools.

The results of tasks 2.1 and 2.2.1 would constitute the basis for developing advanced tools which would be integrated with the best of the Initial Project Management Tool Set tools to iteratively develop an Advanced Project Management Tool Set.

2.2.2.1 Automated Tracking Tools. The first level of advanced tools for integration into the Advanced Project Management Tool Set would be the tools for automating the tracking of product status. These tools would use the Activity Elements as a mechanism for reporting status. Status information relative to activities related to design, coding, configuration, and testing could be obtained directly from an integrated programming support environment such as an APSE. For the near and mid term the status of activities related to buyer functions and producer management functions might require manual entry. The tracking tools would have a common reporting mechanism across the buyer/producer interface which would be the

Activity Elements even though, in the real world, some attributes content may remain the unique purview of either the buyer or producer. Critical to this first level of advanced tools would be the completness of the set of Activity Elements.

2.2.2.2 Automated Indication and Warning Tools. Automated Indication and Warning Tools should be built on top of the Automated Tracking Tools. To support Automated Indication and Warning Tools a set of parameters which bound expected or planned levels must be developed for each of the Activity Elements. These parameters would be project dependent and derived from the management policies and procedures. Management judgment is a key factor in setting the parameters. The Automated Indication and Warning Tools mechanism would be to continuously compare activity status (in real-time where status reporting is automated such as within an APSE) against pre-set activity parameters. It would alert the project manager when activity levels (such as time to complete) exceed the parameters. The Automated Indication and Warning Tools should alert the project manager that activity measures are out of expected bounds. These warnings could materially enhance project managers' effectiveness because they would concentrate management activity on issues that require attention. Activity parameters could be established for all attributes of project activity such as:

a. time to complete
    1. design
    2. code
    3. test
b. module size
c. number of source code change

d. level of code annotation

e. computer time used

f. man hours used

g. available funds

Parameters could also be established which would provide warning of policy violations such as code being compiled before design approval.

2.2.2.3 Automated Decision Support Tools. The Policies and Procedures defined by task 2.1 would provide a framework for Automated Decision Support Tools. Two levels of decisions could be defined, those which could be made within the confines of the established project policies and procedures and those which would require changes to established policies and procedures. Concepts for implementing Automated Decision Support Tools which support the first level of decision could be developed for mid term implementation. The Automated Indication and Warning Tools parameters which relate intra-activity status to policies and procedures, such as "design before code" or "module n must complete unit test before integration testing of build A can begin," form a basis for decision support tools of the "what if" nature which could support project management review of options when alerted by the Automated Indication and Warning Tools.

2.2.2.4 Project Activity Coordinator. In order for the Advanced Project Management Tool Set to be most effective, some form of global communications and coordination interface must exist among all project participants. One part of this interface would exist in the Activity Elements. The Activity Elements would provide a centralized, consistent expression of activity knowledge and need to be stored and maintained in an automated environment. The second part of the interface would be an expression of the project activities' relational semantics. A language for stating such relational

semantics and an interpreter for this language must be created. The Activity Elements and their Relational Semantics Language would form a Project Activity Coordinator. Through the Project Activity Coordinator, management activity could be expressed by updates to the Activity Elements which would record the overall state of the project.

2.2.2.5 Advanced Project Management Tool Set. The implementation concept of the Advanced Project Management Tool Set is to develop prototypes of each previously described tool, add the prototype to the baseline tool set resulting from the Initial Project Management Tool Set and evaluate the new prototype set. The product of this task would be a prototype Advanced Project Management Tool Set. Its purpose would be to demonstrate and evaluate tool concepts and their use. The tool documentation would allow both industrial and DOD managers to tailor and implement the tools for their own environments. The prototype tools would be integrated into the DOD model environments and supported by the Software Engineering Institute.

The Automated Tracking Tools, Automated Indication and Warning Tools, and Automated Decision Support Tools are a natural progression of tool complexity and the strategy should be to implement them in that order. The Automated Tracking Tool is based on Activity Elements which reflect project status. The Automated Indication and Warning Tool requires the capability of the Automated Tracking Tool and a richer model which reflects additional knowledge about project activities such as size and quality. The Automated Decision Support Tool requires the capability of the Automated Indication and Warning Tool. The Automated Tracking Tools, Automated Indication and Warning Tools, and Automated Decision Support Tools would be prototyped in turn and integrated with tools from the Initial Project Management Tool Set which have been proved useful by real experience. The tool

set which results from the addition of each prototype must be exercised on real projects to judge its efficacy. This exercise task is a continuation of the Initial Project Management Tool Set exercise specified in 2.2.1.4. In each instance careful planning must be done to ensure that the results of using the tools are rigorously captured and that the buyer/producer interface is sufficiently robust to support the tools.

The Project Activity Coordinator must evolve from an increasingly rich knowledge base of project activity and the development of a Relational Semantics Language. The Project Activity Coordinator should be the final step in obtaining the Advanced Project Management Tool Set because the Project Activity Coordinator provides a consistent mechanism for communicating management and project activity among all participants. The Project Activity Coordinator would not be dependent on a particular buyer/producer relationship nor would it be dependent on a particular set of policies or procedures or activities. The Project Activity Coordinator could therefore provide the means for the Advanced Project Management Tool Set to be project independent.

2.2.2.6 Deliverables.

- Automated Tracking Tool Prototype, including documentation. (Should be delivered by FY87.)
- Automated Indication and Warning Tool Prototype, including documentation. (Should be delivered by FY88.)
- Automated Decision Support Tool Prototype, including documentation. (Should be delivered by FY89.)
- Project Activity Coordinator Prototype, including documentation. (Should be delivered by FY89.)
- Integrated Advanced Project Management Tool Set Prototype, including documentation, guidelines for use, and courseware. (Should be delivered by FY89.)

- o Evaluation and Test Results. (Should be delivered semi-annually FY88-FY89.)

2.3 Development of Management Skill Educational Concepts

Managers of software on both the buyer and producer side tend to be either software professionals learning management skills on-the-job or professional managers with relatively little experience in software. Each needs to learn some of the skills of the other. Moreover, both need to be made aware of common pitfalls inherent in their position: the manager with software experience tends to become too much involved in technical details while the professional manager, ignorant of software, tends to manage the Work Breakdown Structure instead of the project. This section details four subtasks designed to improve management skills.

2.3.1 Management Job Descriptions

In order to properly develop an educational program for project management personnel, it is necessary to determine exactly what is required of them. This subtask calls for the writing of a set of job descriptions for people involved in project management on both the buyer's and producer's side. A conjecture is that writing the description for the buyer's side will prove more difficult since the buyer's environment is extremely diverse and may require wider knowledge, for example, of application areas and authoritative sources of information. This exercise would document the knowledge, skills, and abilities required for project management and an explicit description of duties. The product of this subtask could be used to identify further educational opportunities, provide models for writing government Position Descriptions, and furnish criteria for contractor project managers during source selection.

2.3.2 Software Engineering Principles

One difference between software engineering and programming is that software engineering involves many programs, many programmers, and the necessity to integrate them. This difference correctly implies that software engineering has a management component. This subtask proposes definition of an educational program to teach those aspects of software engineering needed for management. Emphasis would be on policies and procedures that support good software engineering principles, the influence of software design methodology on project organization, and methodology for reviewing software design documentation.

2.3.3 Project Accounting and Control

This subtask calls for development of a short educational program aimed at the software professional new to management. The program covers elementary management techniques such as work breakdown structures, planning and budgeting, formal accounting systems, and reporting procedures derived from these techniques.

2.3.4 Organizational Analysis

This task calls for investigation into and documentation of the various organizational strategies available to project managers within the constraints imposed by software design methodology. Different organizational structures, such as Chief Programmer Teams or Adversary Test Teams can have a profound effect on project management and the software product. For the development manager who might be constrained by corporate policy there may appear to be very little scope for altering project organization. Yet, the project manager can tailor organizations so as to reinforce certain policies and procedures, if options are identified for him and he is properly educated. The results of this task will therefore be directed towards

assessing the implications of organizational decisions on cost, productivity, and quality.

2.3.5 Management Gaming

This subtask calls for the development of a computer-based gaming system to provide exercise in project management planning and decision making. Such a gaming simulator would build on successes that have been recorded for this technology to cultivate judgment using exercises of real-world project senarios. Improved planning and decision-making skills could be expected to result as managers learn to manage in a controlled learning situation.

2.3.6 Deliverables

- Management Job Descriptions. (Should be delivered by FY84.)
- Software Engineering Principles Course Outline and Teaching Plan. (Should be delivered by FY85.)
- Project Accounting and Control Course Outline and Teaching Plan. (Should be delivered by FY86.)
- Organizational Analysis Report and Recommendations. (Should be delivered by FY87.)
- Management Gaming System. (Should be delivered by FY87.)

3.0 INTERFACES

This task area strategy has identified those tasks necessary to carry out project management objectives. The strategy has concentrated on activities which fall uniquely within the area of project management, realizing that those activities must both be supported by and be supportive of activities within other task areas. The following sections identify interfaces with other task areas that would provide mutual support. These sections will identify input in the form of requirements or products from the Project Management Task Area to other task areas and the output in the form of methods, mechanisms or services which support the Project Management Task Area.

3.1 Measurement

The Project Management Tool Set task would rely heavily on measurement tools as a basis for the decision support and indication and warning tools which form a part of the Project Management Tool Set. The measurement area would also support an evaluation of Project Models and tools which would result from the individual tasks. Table 3-1 identifies the Measurement Task Area interfaces.

3.2 Support Systems

A critical element of the Project Management Tool Set would be its interface with an integrated software support environment. The requirement for consistant data within the entire project environment would be the key to successful management and a robust transfer of knowledge about the project between the buyer and producer organizations and between successive phases of the project lifecycle. Activities of the Support Systems Task Area should be the primary focus for creating an integrated data base which contains knowledge of project activities. Table 3-2 identifies the Support Systems Task Area interfaces.

INPUT	OUTPUT

• Measurement Requirements
• Information Requirements
	• Metrics
	  • Tool Evaluation
	  • Productivity Evaluation
	  • Quality Evaluation
	  • Process & Product Evaluation
	  • Decision Effectiveness Evaluation
	  • Progress (cost, schedule & technical performance relationships)
	  • Cost Effectiveness
	  • Personnel Effectiveness
	• Information to Validate Models & Metrics
	• Measurement Methods, Tools, Support and Training

Table 3-1
MEASUREMENT INTERFACES

INPUT	OUTPUT
• Information Requirements (what data when and how much) • Feedback from Initial Project Management Tool Set Usage on Pilot Projects • Management Methods, Standards and Tools	• Data Base Integration Methodology • Tool Integration Methodology • Minimum Set of Tool Standards • Data Standards • Knowledge Base

Table 3-2
SUPPORT SYSTEMS

3.3 Acquisition

A robust flow of information across the buyer/producer interface has been identified as a central issue with regard to successful project management. A free flow of information across the interface is often inhibited or not supported by contractual relationships. If DoD is going to successfully leverage initiative funds by seeding Project Management Tool Set efforts within industry, then ways must be found to make wide use of the results of those efforts within the DoD community. This concept extends to being able to specify the best of industry technology on competitive acquisitions. In order to make these concepts viable, acquisition practice must change. The Acquisition Task Area should be responsible for identifying impediments to these concepts and recommending changes to contractual policy and regulation to remove the impediments. Table 3-3 identifies the Acquisition Task Area interfaces.

INPUT	OUTPUT
o Data Exchange Requirements	o Ways to acquire technology for Gov't use & write provisions to protect commercial interests
o Management Methods, Standards and Tools	o Innovative acquisition policies to induce the use of advanced project management methods and tools
	o Contractual mechanisms for reducing cost and schedule risk throughout the contracts term
	o Data Exchange Agreement between buyer and producer.

Table 3-3
ACQUISITION

3.4 Systems

In the long term, the Project Management Tool Set shall consist of an activity coordinator which acts as the central communications interface among project members. This interface is expressed in terms of Activity Elements which are intended to be so complete that in combination they record the overall state of the project. In order to realize this concept the Systems Task Area must provide such tools as very high level languages, knowledge base techniques and artificial intelligence concepts. Table 3-4 identifies the System Task Area interfaces.

3.5 Human Resources

Policies and Procedures to govern the software lifecycle are very closely related to software engineering concepts and have a material effect on the resulting product. This is in fact the management component of software engineering. Managers also must be educated to make real-time decisions which are both technical and administrative. Providing curricula to support these educational requirements should be the responsibility of the Human Resources Task Area. Table 3-5 identifies the Human Resources Task Area interfaces.

3.6 Human Engineering

In order to provide usable and effective tools the Project Management Tool Set development requires a strong input from the Human Engineering Task Area to ensure that the tools are user friendly and supportive of the manager. Table 3-6 identifies the Human Engineering Task Area interfaces.

INPUT	OUTPUT
• Management Methods, Standards and Tools	• Expert System Technology and Tools
• Advanced Project Management Tool Set Concepts	
• Decision Support Concepts	

Table 3-4
SYSTEMS

INPUT	OUTPUT
• Management Related Component of Software Engineering	• Better Educated Managers
• Requirements for Decision Making Skills	
• On Line Manager Exercise Tools	
• Management Job Descriptions	

Table 3-5
HUMAN RESOURCES

INPUT	OUTPUT
• Manager/Machine Functional Interface Description	• Manager/Machine Tool Interface Requirements Specifications
• Feedback from Initial Project Management Tool Set	
• Management Methods, Standards and Tools	

Table 3-6
HUMAN ENGINEERING

4.0 SUMMARY

4.1 Accomplishments

The tasks described in this task area strategy have been designed to improve the capability of the project manager to deal with the problems discussed in section 1.3 by developing methods to identify and relate project activities so that they support available software engineering concepts, developing tools to aid the manager in focusing his time and resources, and providing educational material and concepts to support project manager education.

4.1.1 Improved Visibility

Tasks have been described which provide a consistant mechanism for understanding project activities and their interrelationships. This mechanism would provide for the organization of project activities and the transfer of knowledge about those activities throughout the project team on both sides of the buyer producer interface. Tools are defined which would aid the project manager in tracking project status, identifying potential problems and answering questions relating to management options within the scope of establish policy and procedures.

4.1.2 Improved Forcasting

The increased understanding of project activities and their interrelationships and the ability to more effectively plan, organize, track progress, identify trouble spots, and perform conditional analysis of options would improve forecasting both prior to and during project implementation. Of special importance would be the ability to make more accurate estimates of cost to complete.

4.1.3 Improved Product

The ability to tailor project activities, policy and procedures to reinforce good software engineering practice should provide for improved products. Advanced tools would provide the ability to identify and solve problems in real-time so that product quality and schedule can be maintained. Enhanced knowledge about the product and the activities which resulted in that product would increase the ability of software support organizations to make effective changes.

4.1.4 Improved Organizations

The methods and supporting tools developed within the scope of this task area provide a mechanism for tailoring organizations and supporting information flows as well as the means for consistantly reporting the status and the results of management action on both the project and the organizational elements.

4.1.5 Improved Management Skills

Tasks have been identified which support improved education for project managers in the use of software engineering principles, the structuring of organizations, and project accounting and control. Tools would be developed for enhancing and exercising of management skills.

4.1.6 Potential

Project management could become significantly more effective, using todays software engineering principles, by increasing the power and use of automated tools and improving the timeliness and content of project information flow. The use of integrated software support environments like the Ada APSE to capture information about the status of project activities coupled with improved information flow among project participants on both sides of and across the buyer/producer interface could enhance project managers ability to

understand program status. In order to make good use of the increased information availability, automated tools would be a necessity.

Today, much of the knowledge about sofware projects is captured only in the form of the end product. Because the end product is designed to perform a function and not to relate the concepts and decisions embedded in its evolution, a better way to capture project knowledge is required. One approach is through the use of more formal requirements definition and design methodologies. The capture of requirements in formal semantics and traceability of these requirements through a formal design process not only enhances the control of the development process but also enhances the transfer of knowledge about the product to those who have need to change it.

4.2 Priorities

The Project Management Functional Analysis provides the baseline for the rest of the task area and therefore is of the highest priority within the task area. In the same way that an understanding of the Project Management Function is critical to their performance, educating managers in the principles of the Project Management Function is critical to their practice. The Development of Management Skills Educational Concepts must therefore be next in task priority. Because the automated tools can only be developed based on a clear understanding of the functions which they are to perform and can only be used effectively by people who understand the principles which the tools are designed to support, the development of advanced tools must be third in the priority order.

END

FILMED

6-83

DTIC